CLAIMS

1. A device for acquiring the position coordinates of a source of mechanical waves optionally generated by an impact on the surface of a plate (PLQ) of finite dimensions comprising a set of acoustic sensors (PZT00 to PZT11) each formed of a pair of piezoelectric transducers (PZTa, PZTb) situated facing one another on either side of the plate, the device comprising processing means for determining the coordinates of the source by analyzing the difference in propagation times of the acoustic waves generated by the source to the various sensors, a device characterized in that, the processing means comprise in association with each sensor (PZT00 to PZT11) a respective electronic circuit comprising in cascade, means for digitizing the amplified signal around a predetermined frequency, and associated with means for limiting the digitization to a time window starting before the acoustic waves reach a sensor and ending after the acoustic waves have reached said sensor.

2. The device as claimed in claim 1, characterized in that the sensors are four in number and the piezoelectric transducers of each sensor are disks or wafers of piezoelectric ceramics stuck to either side of the plate, in such a way that the four sensors form on the plate the vertices of a rectangle whose center (O) constitutes the origin of the coordinates of a cartesian reference frame whose x and y axes are parallel to at least two sides of the rectangle defined by the four sensors.

3. The device as claimed in claims 1 or 2, characterized in that the determination of the position coordinates is achieved via a trio of sensors taken from among the four sensors, said trio corresponding to the three sensors nearest to the source, each trio

being responsible for detecting the coordinates in a given quadrant of the cartesian reference frame defined by the sensors.

4. The device as claimed in claims 1 to 3, characterized in that the locating of a point of interaction of the source with the plate consists in extracting the ultrasound frequency component in the vicinity of 100 kHz generated by the impact of a hard object such as a fingernail, a metal key, a ballpoint pen, a hard plastic in the form of a rod and in determining the largest of the differences in absolute value of the times of flight between two sensors of two first pairs (PZT00, PZT01) identified by gx = 0 or (PZT10, PZT11) identified by gx = 1, on the one hand, and two pairs of two sensors (PZT00, PZT10) identified by gy = 0 and (PZT01, PZT11) identified by gy = 1, on the other hand, so that the cartesian coordinates of the point of impact (xr, yr) on the plate are given by the formula:

$$x_r = (-1)^{gx} \frac{\Delta txg \left(q \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta txg^2) (4 p^2 + 4 q^2 - v^2 (\Delta txg - \Delta tyg)^2) \Delta tyg^2 (4 q^2 - v^2 \Delta tyg^2)} + p^2 v^2 \Delta tyg^2 (-4 q^2 + v^2 \Delta tyg (-\Delta txg + \Delta tyg)) \right)}{4 p \Delta tyg (q^2 v^2 \Delta txg^2 + p^2 (-4 q^2 + v^2 \Delta tyg^2))}$$

$$y_r = (-1)^{gy} \frac{q v^2 \Delta txg (-4 p^2 + v^2 \Delta txg (\Delta txg - \Delta tyg)) \Delta tyg + \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta txg^2) (4 p^2 + 4 q^2 - v^2 (\Delta txg - \Delta tyg)^2) \Delta tyg^2 (4 q^2 - v^2 \Delta tyg^2)}}{4 (q^2 v^2 \Delta txg^2 + p^2 (-4 q^2 + v^2 \Delta tyg^2))}$$

or p and q designate the position of the sensors with respect to the center O of the rectangle, v, the velocity of the plate mode selected by the particular arrangement of the pair of transducers forming a sensor, Δtxg, (respectively Δtyg) the difference in the propagation times of the wave packet generated by the impact between the sensors of one of the two first pairs (respectively of one of the next two pairs), selected by the value of the index gx (respectively gy) equaling 0 if the coordinate yr (respectively xr) is negative and 0 otherwise and being written Δtx_0 if gx = 0 or Δtx_1 if gx = 1 (respectively Δty_0 if gy = 0 or

Δty_1 if gy = 1).

5. The device as claimed in claims 1 to 4, characterized in that said electronic circuits associated with the sensors PZTij (i or j equaling 0 or 1) comprise in cascade two broadband preamplifier stages (A1ij, A2ij), a selective amplifier stage FCHij centered on a frequency of around 100 kHz, a squaring stage (SQij), a peak detector stage (ENVLij), and an integrator stage (INTGRij), a stage PMOSij for adaptation to a logic level yielding a synchronizing signal SYNCij, said synchronization signal SYNCij triggering, via a logic transition, a flip-flop FFij responsible for ordering the stoppage of the analog digital converter CANij and the transferring into memory FIFOij (first in-first out) of the digitized value of the signal emanating from the selective filter FCHij diverted to the converter CANij.

6. The device as claimed in claims 1 to 5, characterized in that the processing means comprise downstream of said electronic circuits associated with the respective sensors a programmable logic module (wavepro4) driven by a microcontroller μC of an arithmetic and logic unit, of input/output ports operating on an interrupt basis, of RAM random access memory, of ROM type program memory, of a real-time clock, of ports for capturing the instants of switching of the signals SYNCij, of communication ports, of data buses and of address buses.

7. The device as claimed in claims 1 and 6, characterized in that the microcontroller μC is furnished with software means for measuring the time interval TTij separating the head of a wave packet t_{HDij} from the rising edge of the synchronization signal SYNCij, said software means consisting in determining the instants of zero-crossing of the digitized signal

on the basis of the end of the digitization window commencing on the rising edge of SYNCij, while a test of decrease on the successive sum values of the amplitudes between the zero-crossings, that is to say a test on the mean value of the signal per half-period, makes a decision regarding the continuation of the search algorithm for the instant t_{HDij}. When the mean value over a half-period is equal to the output value from the sampler in the absence of any signal, to within a threshold discrepancy, the algorithm is stopped, and the mean value is regarded as being the origin instant t_{HDij} of the packet.

8. The device as claimed in claims 1 to 7, characterized in that the values of the bits gx and gy are determined by the following formulae:

$$\left\{\begin{array}{l}
\Delta t_{x0}=abs\left[TT_{01}-TT_{00}+(-1)^{SS_{x0}}XBUF\&\Delta txs_0\right]\\
\Delta txs_0=\left(\left(SR_{01}\&\overline{SR_{00}}\right)\#\left(\overline{SR_{01}}\&SR_{00}\right)\right)\\
\Delta t_{x1}=abs\left[TT_{11}-TT_{10}+(-1)^{SS_{x1}}XBUF\&\Delta txs_1\right]\\
\Delta txs_1=\left(\left(SR_1\&\overline{SR_0}\right)\#\left(\overline{SR_1}\&SR_0\right)\right)\\
SS_{x0}=SR_{00}\&\overline{SR_{01}}\\
SS_{x1}=SR_0\&\overline{SR_1}
\end{array}\right.
\quad
\left\{\begin{array}{l}
\Delta t_{y0}=abs\left[TT_{10}-TT_{00}+(-1)^{SS_{y0}}XBUF\&\Delta tys_0\right]\\
\Delta tys_0=\left(\left(SR_0\&\overline{SR_{00}}\right)\#\left(\overline{SR_0}\&SR_{00}\right)\right)\\
\Delta t_{y1}=abs\left[TT_{11}-TT_{01}+(-1)^{SS_{y1}}XBUF\&\Delta tys_1\right]\\
\Delta tys_1=\left(\left(SR_1\&\overline{SR_{01}}\right)\#\left(\overline{SR_1}\&SR_{01}\right)\right)\\
SS_{y0}=SR_{00}\&\overline{SR_0}\\
SS_{y1}=SR_{01}\&\overline{SR_1}
\end{array}\right.$$

$$\begin{array}{l}
g_x=0 \text{ if } \Delta t_{y0}>\Delta t_{y1} \text{ and } \left[TT_{10}-TT_{00}+(-1)^{SS_{y0}}XBUF\&\Delta tys_0\right]<0\\
\quad \text{or if } \Delta t_{y1}>\Delta t_{y0} \text{ and } \left[TT_{11}-TT_{01}+(-1)^{SS_{y1}}XBUF\&\Delta tys_1\right]<0\\
g_x=1 \text{ otherwise}
\end{array}$$

$$\begin{array}{l}
g_y=0 \text{ if } \Delta t_{x0}\geq \Delta t_{x1} \text{ and } \left[TT_{01}-TT_{00}+(-1)^{SS_{x0}}XBUF\&\Delta txs_0\right]<0\\
\quad \text{or if } \Delta t_{x1}\geq \Delta t_{x0} \text{ and } \left[TT_{11}-TT_{10}+(-1)^{SS_{x1}}XBUF\&\Delta txs_1\right]<0\\
g_y=1 \text{ otherwise}
\end{array}$$

9. The device as claimed in claims 1 to 8, characterized in that the acoustic plate is a laminated glass consisting of an assemblage of plates of like thickness, stuck together by a polymer film.

10. The device as claimed in claims 1 to 9, characterized in that the piezoelectric transducers of a sensor are ferroelectric ceramics whose polarization vectors are oriented symmetrically with respect to the thickness of the plate and whose electrical connections are in parallel.

11. The device as claimed in claims 1 to 9, characterized in that the piezoelectric transducers of a sensor are ferroelectric ceramics whose polarization vectors are oriented antisymmetrically with respect to the thickness of the plate and whose electrical connections are in antiparallel.

12. The device as claimed in claims 1 to 11, characterized in that the piezoelectric ceramics are disks or plates whose lower electrode, in contact with the plate, is brought to a small upper face portion, while remaining insulated from the upper electrode by an electrical insulating guard strip.

13. The device as claimed in claims 1 to 11, characterized in that one of the sensors for example PZT10 is able to be switched into an emitter of an ultrasound wave packet so as to trigger a measurement of velocity of propagation of the acoustic waves in at least two different directions given by the positions of the other sensors.

14. The device as claimed in one of the preceding claims, constituting a peripheral interface with a computer fitted with a screen.

15. The device as claimed in claim 14, characterized in that the acoustic plate also serves as a display screen for visualization by scattering of projected light, either by frosting at least one of the faces of the glass plates, or by using a translucent polymer

film, optionally colored and optionally combined with an effect of light concentration by means of a Fresnel lens.

16. The device as claimed in claims 14 and 15, characterized in that the axes of the screen reference frame and of the acoustic plate are colinear.

17. The device as claimed in claims 14 to 16, characterized in that a homothetic correspondence between a pixel (N_{qx}, N_{qy}) of the screen reference frame and a physical point (x_r, y_r) of the plate opposite the graphical pixel is established by automated calibration according to the following operations:

- displaying by the software of a target at various positions with known screen coordinates and measuring of the corresponding physical coordinates. For example, a first target is displayed at $N_0(i, j)$ where i and j are screen coordinates, ready of the origin of the graphical coordinates. This target is displayed on the acoustic plate at the real coordinates $N_0(x_a, y_c)$. An impact carried out opposite the target makes it possible to gather these real coordinates via the acquisition device. A second target is then displayed at $N_1(k, l)$ ready of the maximum coordinates of the graphical interface. The corresponding real coordinates $N_1(x_b, y_d)$ are obtained through an impact opposite the target. The graphical coordinates (N_{qx}, N_{qy}) of a pixel with real coordinates (x_r, y_r) may then be deduced from the formula

$$\left\{\begin{array}{l} N_{qx}=i+(k-i)\dfrac{(x_r-x_a)}{(x_b-x_a)} \\ N_{qy}=j+(l-j)\dfrac{(y_r-y_d)}{(y_c-y_d)} \end{array}\right\}$$

• a reference target is displayed a last time at the center of the graphical screen. The impact carried out opposite the target is converted into screen coordinates according to the above formula. The calculated position is compared with the reference position. If the discrepancy is below a certain threshold, the calibration operation is validated. Otherwise it is repeated.

18. The device as claimed in claims 1 to 17, characterized in that the acoustic plate constitutes a graphical pointing peripheral capable of emulating another pointing peripheral such as for example a peripheral of mouse type, an impact on the plate at a given position then being interpreted according to a particular coding, as a click or a double click carried out on the corresponding screen coordinates and triggering the execution of programs associated with an icon situated opposite the impact.

19. The device as claimed in claims 1 to 18, characterized in that the zone of emulation of the mouse events (click, double click, etc.) is limited to an authorized portion of the screen zone exhibiting the form of a rectangle defined by the X, Y coordinates in pixels of one of its corners as well as its width L and its height H in pixels, it being possible for these values to be entered directly at the keyboard or to be deduced by acquiring the coordinates of the impacts in the corners of the authorized zone to be defined.

20. The device as claimed in claims 1 to 19, characterized in that it is furnished with software means making it possible to produce a floating toolbar, permanently accessible, consisting of several icons K03, K04 ensuring when they are struck by an impact:

• the appearance (K04) on the screen of an alphanumeric keyboard, two of whose keys K01 and K02 make provision

respectively for its upward movement and its reduction to the floating menu bar,

- the fast and circular movement (K03) of the toolbar into one of the four corners of the screen, designated by the direction of the arrow represented on the icon.

21. The device as claimed in claims 1 to 20, characterized in that it is furnished with software means such that the portion of the plate which does not serve as a screen is also interactive and is configured as an extension of the screen zone, in particular an impact produced to the left (respectively, to the right, above, below) of the screen zone moves the content of the screen toward the right (respectively left, below, above), thus making it possible to read a document of much greater size than the size of the screen zone.

22. The device as claimed in claims 1 to 21, characterized in that it is furnished with software means such that the portion of the plate which serves as a screen is regarded as a special zone making it possible to quit or to switch from any software application managing the execution of groups of programs associated with various zones of the plate which are situated off-screen. Conversely, the system is furnished with software means such that any impact produced on the plate outside the screen zone is associated with the execution of a chosen application managing the workspace situated off-screen, such as for example the application where, on the basis of the homothetic correspondence established between the pixels of a digital photograph of the acoustic plate and the physical coordinates of these pixels on the acoustic plate, groups of programs are executed following an impact on a given zone of the plate.

23. The device as claimed in claims 14 to 22,

characterized in that it is furnished with software means such as client/server type protocols allowing the graphical interface to be connected, via a modem or a network card, to an Internet access provider.

24. The device as claimed in claims 14 to 22, characterized in that it contains software means making it possible to update the multimedia content (picture, sound, video) available on the host computer of the graphical interface from a remote computer.

25. The device as claimed in claims 1 and 24, characterized in that the electronic circuits associated with the respective sensors PZTij comprise downstream of said broadband amplification means A2ij a bypass to means of frequency enrichment of the audible acoustic signal generated by the impact on the plate, as well as means for reconverting the enriched signal into an analog signal and sending it to loudspeakers so as to mask the nuisance caused by the impact in the form of a different sound reproducing for example the noise of a percussion instrument within a symphonic composition, or the noise of an animal or of a natural event, said means of enrichment being implemented at the very instant IntHF at which the first of the four synchronization signals SYNCij switches logic level.